Michigan Operations   The Dow Chemical Company
                                                     Midland, MI 48674

October 15, 2007

George Bruchmann
Constitution Hall
525 West Allegan Street
Lansing, Michigan 48909

Subject: Work Plan for Exposure Unit Sampling, Middle and Lower Tittabawassee
River

The Dow Chemical Company is hereby submitting an electronic copy of the Work
Plan for Exposure Unit Sampling on select Priority 1 and 2 properties in the Middle
and Lower Tittabawassee River project study areas. We are submitting this
information in accordance with the Tittabawassee River Remedial Investigation Work
Plan Compliance Schedule, dated July 24, 2007, for MDEQ review and approval.
Hard copies of this document will be delivered separately.

We look forward to working with you and the MDEQ staff during your review of this
information, to ensure the timely completion of the Exposure Unit Sampling on select
Priority 1 and 2 properties by November 15, 2007.

"I certify under penalty of law that this document and all attachments were prepared
under my direction or supervision according to a system designed to assure that
qualified personnel properly gather and evaluate the information submitted. Based on
my inquiry of the person or persons who manage the system, or those persons directly
responsible for gathering the information, the information submitted is, to the best of
my knowledge and belief, true, accurate, and complete. I am aware that there are
significant penalties for submitting false information, including the possibility of fine
and imprisonment for knowing violations."

Sincerely,

Ben Baker
Senior Environmental Project Leader
Sustainable Development
1790 Building
Midland, MI 48674

Cc: Cheryl Howe, Michigan Department of Environmental Quality
        Peter Simon, Ann Arbor Technical Services, Inc.
        Philip Simon, Ann Arbor Technical Services, Inc.

TECHNICAL MEMORANDUM

TO: Allan Taylor, Michigan Department of Environmental Quality

FROM: Peter M. Simon
                  Philip B. Simon

DATE: October 15, 2007

RE: 2007 *GeoMorph*® Work Plan for Exposure Unit Sampling and Evaluation

INTRODUCTION

Consistent with the *2007 GeoMorph*® *Sampling and Analysis Plan (2007 SAP) for the Upper and Middle Tittabawassee River* approval letter dated July 12, 2007, Ann Arbor Technical Services, Inc. (ATS) has developed a plan for sampling select Priority 1 and 2 properties in the Middle and Lower Tittabawassee River project study areas. This memorandum serves to address the requirement for Dow Chemical Company to submit a "Work Plan for Exposure Unit Sampling" required in the July 24, 2007 MDEQ Compliance Schedule.

BACKGROUND

A principle of the *GeoMorph*® sampling design is that there is an association between furan and dioxin concentrations in the floodway soils and distinct fluvial deposition areas. This association is best characterized by applying geomorphological principles and fluvial processes. The *GeoMorph*® sampling design is based on collecting representative soil samples from distinct fluvial geomorphic surfaces to characterize the furan and dioxin concentrations associated with the soils from those geomorphic surfaces.

During the development of the *2006 SAP for the Upper Tittabawassee River (2006 SAP)*, MDEQ expressed a desire to statistically calibrate and verify the sample design by comparing the efficiencies and results generated by the fate and transport-based *GeoMorph*® process to that of random sampling designs. During 2006, this site characterization process was validated against classic investigation methods (fixed-transect and random-on-grid sampling schemes) using standard statistical tools. In the February 1, 2007 *UTR GeoMorph*® *Pilot Site Characterization Report,* it was concluded that geomorphologic information can make sampling strategies more efficient, both by reducing the number of samples needed to characterize the spatial distribution

of contamination and by targeting areas where contaminants occur preferentially over areas where they do not.

During the development of the *2007 SAP*, MDEQ expressed a desire to expand the statistical calibration and verification of the *GeoMorph*$^®$ sample design to include an evaluation of Exposure Units according to Michigan PA 451, Parts 201 and 111. MDEQ formally included this requirement in the July 24, 2007 Compliance Schedule for the Tittabawassee River Site Investigation (Compliance Schedule). In response to this Compliance Schedule, a process outline for assessing adequacy of site characterization and providing the basis for Exposure Unit evaluations on Priority 1 and 2 was submitted to MDEQ on August 3, 2007. On September 17, 2007, ATS proposed sampling locations for evaluation of Exposure Units on Priority 1 and 2 properties within the Lower Tittabawassee River (LTR) Study Area. This Work Plan is a follow-up submittal pursuant to the July 24, 2007 MDEQ Compliance Schedule.

Based on the "residential land use" geodatabase layer provided to ATS by CH2M Hill in 2006, a substantial number of Priority 1 and 2 residential properties are being sampled as part of the *2007 SAP*. ATS recently reviewed the 2007 zoning and future land use designations assigned by Saginaw County Zoning Department, and found a substantial difference in the boundaries for "residential land use." The significance of the difference between these two information sources is being evaluated at this time.

On September 25, 2007, the Site Investigation update identified one sampling location on "residential" property in the MTR with reported that exceeds the IRA/PCAP Decision Tree threshold (concentration greater than 1,000 ppt TEQ in the upper 1 foot of soil). This sole location was identified by comparing 2007 site characterization data to the CH2M Hill "residential land use" designations. It is anticipated that using the Saginaw County Zoning Department zoning and future land use boundaries will result in a significantly greater number of properties exceeding the "residential land use" PCAP/IRA trigger.

EXPOSURE UNIT SAMPLING AND EVALUATION ON PRIORITY 1 AND 2 PROPERTIES

The following bullets summarize the approach that will be used to conduct sampling and validate the *GeoMorph*$^®$ process for evaluation of exposure unit concentrations on Priority 1 and 2 properties in the Middle and Lower Tittabawassee River study areas.

- Implement the *2007 SAP* for the MTR to determine where sampling locations on Priority 1 and 2 properties with 2007 "residential" land use designations have concentrations that exceed the IRA/PCAP Decision Tree thresholds and require step-out sampling. A procedure has been established to initiate step-out sampling based on the thresholds identified in the IRA/PCAP Decision Tree. Sampling locations with reported concentrations on "residential" land use parcels defined by

Saginaw County that exceed the IRA/PCAP Decision Tree thresholds and require step-out sampling are presented in Attachment A. The IRA/PCAP Step-out sampling plan for such properties is included in Attachment B.

- Conduct overbank sampling in select Reaches of the LTR to determine where Priority 1 and 2 properties may reasonably be expected to have concentrations above applicable criteria. Use the iterative process for additional sampling locations, as needed. The proposed sampling locations for the LTR Priority 1 and 2 properties are included in Attachment C.

- Establish statistical populations and sub-populations based on the following categories:

  o <u>Geomorphic Surface Categories</u>, including: in-channel, shoreline, low, low intermediate, intermediate, high, natural levee (post-industrial levee), historic natural levee (pre-industrial levee), geomorphic wetland, upper high, upland, and tributary;

  o <u>Geomorphic Proximity Categories</u>, including: in-channel, bank, ridge and swale, near bank, wetland complex, away, and disturbed/other;

  o <u>Causation and River Flow Lines Categories</u>, including: back water effects, distance of travel, sedimentation velocity/settling time, and similar deposition influences;

  o <u>Land Use Categories</u>, including: residential, commercial/institutional, industrial, extractive, developmental, agricultural, forest land, open/other, streams and waterways;

- Develop descriptive statistics on populations and/or sub-populations (individual geomorphic surfaces and possible reach level grouping of like surfaces, if appropriate); statistical evaluations will consider a number of variables including number of data values, satisfaction of normal distribution model assumptions (independence, normal distribution), and potential influence of outliers on data analyses to select the most appropriate parametric and/or nonparametric statistical tests. Example work product outputs for the descriptive statistics are included in Attachment D. Example descriptive statistics include:

  o Population Distribution Type (normal, lognormal);

  o Shape of the Distribution (coefficient of variation, skewness or kurtosis, etc.);

  o Test for Outliers (Grubbs, Dixon's, Rosner's, etc.);

o Measures of central tendency (mean, median, every 10th percentile, mode, interquartile mean, etc.);

o Measures of statistical variability (standard deviation, variance, analysis of variance, range, interquartile range, average deviation, etc.);

o Establish measures of confidence (95% mean UCL, 95% median UCL, etc.);

- Establish Surface Weighted Average Concentration (SWAC) polygons based on geomorphic surfaces and statistical evaluation of populations and/or sub-populations; example work product outputs of the SWAC polygons are included in Attachment E;

- Based on the results of the *GeoMorph*® characterization, a subset of these properties may be selected for further sampling to refine the understanding of the spatial distribution of contamination in and between the identified surfaces within a Reach;

- Complete adequacy of characterization analysis that evaluates the sample size necessary to achieve false positive and false negative rates at various criteria and confidence levels. Example work product outputs of the adequacy of characterization analysis are included in Attachment F;

- Complete existing condition SWAC analysis for the UTR, MTR, and select LTR reaches.

SCHEDULE

11/15/2007:	Complete Exposure Unit Sampling on select Priority 1 and 2 Properties in the Middle and Lower Tittabawassee River
10/31/2007:	Submit Technical Memorandum: Surface Weighted Average Concentration Analysis, *GeoMorph*® Site Characterization of the Tittabawassee River
03/01/2008:	Submit results of Exposure Unit sampling as part of the Site Characterization Report on 2007 *GeoMorph*® Sampling and Analysis Plan for the Upper and Middle Tittabawassee River
03/01/2008:	Submit results of SWAC analysis for the UTR, MTR, and select LTR reaches as part of the 2007 Site Characterization Report

Attachment A

Sampling Locations On Residential Properties

That Exceed IRA/PCAP Decision Tree Thresholds

Middle Tittabawassee River

Overbank Samples and Land Use, " Middle Tittabawassee River"
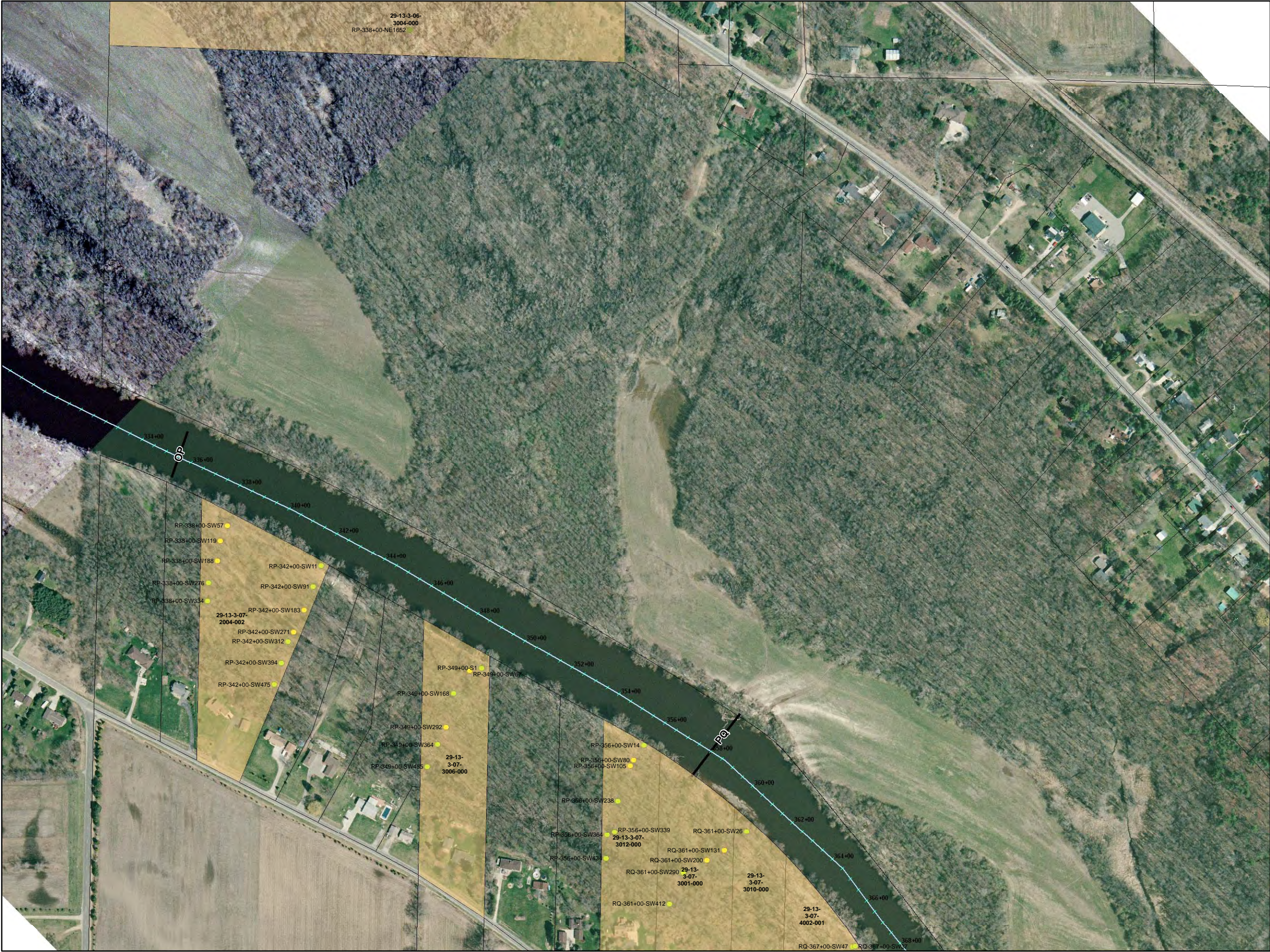
Soil TEQ Concentration

- ● > 15,001
- ● 5,001 - 15,000
- ● 1,001 - 5,000
- ● 101 - 1,000
- ○ < 100

- ● Proposed Samples
- Stations
- ▬ Reach Break
- Saginaw County Tax (Residential)

0   350   700 Feet

Overbank Samples and Land Use, " Middle Tittabawassee River"

Soil TEQ Concentration

o v e r b a n k
- ● > 15,001
- ● 5,001 - 15,000
- ● 1,001 - 5,000
- ● 101 - 1,000
- ○ ● < 100

- ● Proposed Samples
- Saginaw County Tax (Residential)
- Stations
- — Reach Break

0   350   700 Feet

Drawn By: JAT | Date: Oct. 14, 2007
Checked By: PS | Edited By: JAT

Reach Lower Q, R, and Upper S

GeoMorph®
Landuse and Surface ETEQ

Middle Tittabawassee River
Midland, Michigan

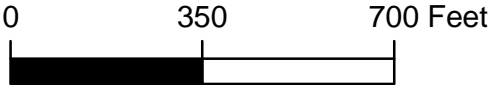# Overbank Samples and Land Use, " Middle Tittabawassee River"

Soil TEQ Concentration

- ● > 15,001
- ● 5,001 - 15,000
- ● 1,001 - 5,000
- ● 101 - 1,000
- ● < 100

● Proposed Samples

▨ Saginaw County Tax (Residential)

✓ Stations

▬ Reach Break

N W E S

| 0 | 350 | 700 Feet |

ATS
ANN ARBOR TECHNICAL SERVICES, INC.

Drawn By:	JAT	Date: Oct. 14, 2007
Checked By:	PS	Edited By: JAT

Reach Lower S, T, and Upper U

GeoMorph®
Landuse and Surface ETEQ

Middle Tittabawassee River
Midland, Michigan

ET Project Number: 91803
ET Map File Location:
MTR proposed samples with landuse_20071014.mxd

2007 Ann Arbor Technical Services, Inc.
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Sample labels on map:
RS-416+00-NE445, RS-416+00-NE510, RS-416+00-NE552, RS-416+00-NE340, RS-416+00-NE160, RS-416+00-NE22, 29-13-3-17-2001-000, RS-421+50-NE686, RS-421+50-NE600, RS-421+50-NE492, RS-421+50-NE550, RS-421+50-NE289, RS-421+50-NE132, RS-421+50-NE43, RS-427+50-NE532, RS-427+50-NE563, RS-427+50-NE477, RS-427+50-NE427, RS-427+50-NE359, 29-13-3-17-1005-000, RS-427+50-NE205, RS-427+50-NE136, RS-427+50-NE104, RS-427+50-NE17, RS-427+50-NE52, 29-13-3-17-1007-001, RT-433+00-NE346, RT-433+00-N6, RT-433+00-NE256, RT-433+00-NE184, RT-433+00-NE84, RT-433+00-NE15, 29-13-3-17-1019-000, RU-441+00-NE162, RU-441+50-NE157, RU-441+50-NE181, RU-441+50-NE122, RU-441+50-NE161, RU-441+50-NE89, RU-441+50-NE7, 29-13-3-17-1008-000, RU-446+00-NE265, RU-446+00-NE189, RU-446+00-NE66, RU-446+00-NE11, RU-452+50-NE475, RU-452+50-NE279, RU-452+50-NE128, RU-452+50-NE23, RU-452+50-N2

Overbank Samples and Land Use, " Middle Tittabawassee River"

Soil TEQ Concentration

Overbank
- 🔴 > 15,001
- 🟠 5,001 - 15,000
- 🟡 1,001 - 5,000
- 🟢 101 - 1,000
- 🟢 < 100

- ⚫ Proposed Samples
- 🟧 Saginaw County Tax (Residential)
- ✓ Stations
- ▬ Reach Break

N
W — E
S

0   350   700 Feet

Reach Lower U, V, and Upper W

GeoMorph®
Landuse and Surface ETEQ
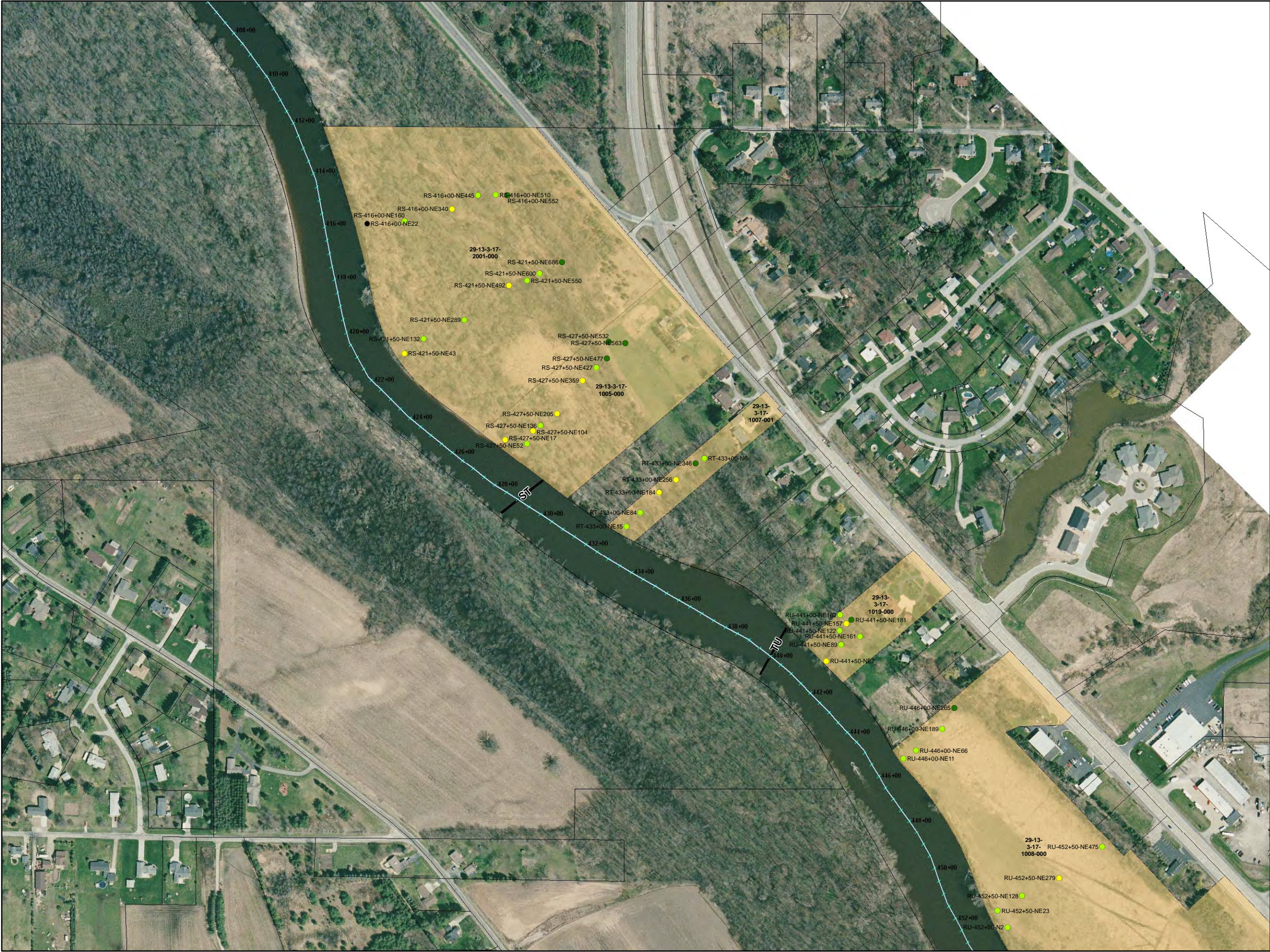
Middle Tittabawassee River
Midland, Michigan

Overbank Samples and Land Use, " Middle Tittabawassee River"

Soil TEQ Concentration

Overbank

- ● > 15,001
- ▲ 5,001 - 15,000
- ● 1,001 - 5,000
- ● 101 - 1,000
- ○ < 100

● Proposed Samples

▨ Saginaw County Tax (Residential)

✎ Stations

▬ Reach Break

Map labels:
- 486+00
- 498+00
- 500+00
- 29-13-3-21-2014-000
- RW-501+00-NE209
- RW-501+00-NE68
- 502+00
- 504+00
- WX
- 506+00
- 508+00
- RX-509+50-NE346
- RX-509+50-NE270
- RX-509+50-NE124
- RX-509+50-NE203
- RX-509+50-NE12
- 29-13-3-21-2022-000
- 510+00
- 512+00
- 514+00
- RX-515+00-NE122
- RX-515+00-NE210
- RX-515+00-NE40
- RX-515+00-NE9
- 516+00
- 518+00
- 29-13-3-21-4012-000
- 520+00
- RX-522+50-NE379
- RX-522+50-NE232
- RX-522+50-NE252
- RX-522+50-NE156
- 527+00 RX-522+50-NE127
- RX-522+50-NE2
- RX-522+50-NE21
- 524+00
- 526+00
- XY
- 528+00
- 530+00

Scale: 0 — 350 — 700 Feet

Compass: N, S, E, W

Drawn By:	JAT	Date: Oct. 14, 2007
Checked By:	PS	Edited By: JAT

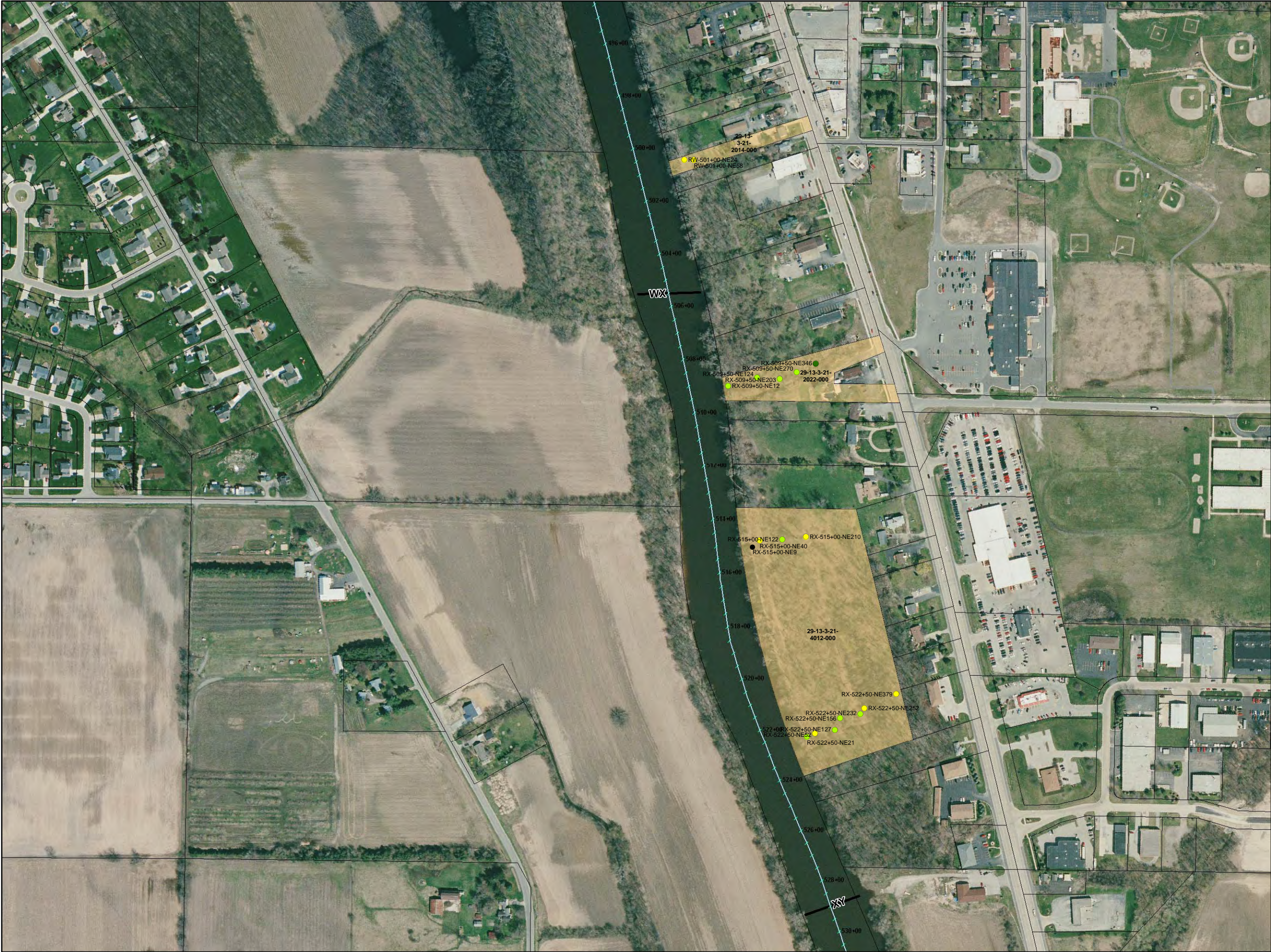**Reach Lower W and X**

GeoMorph®
Landuse and Surface ETEQ

Middle Tittabawassee River
Midland, Michigan

ET Project Number: 91803
ET Map File Location:
MTR proposed samples with landuse_20071014.mxd

Overbank Samples and Land Use, " Middle Tittabawassee River"

Soil TEQ Concentration
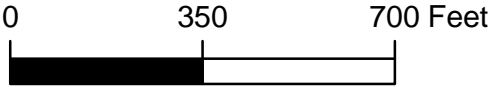
Overbank:
- ● > 15,001
- ● 5,001 - 15,000
- ● 1,001 - 5,000
- ● 101 - 1,000
- ○ < 100

- ● Proposed Samples
- ▦ Saginaw County Tax (Residential)
- Stations
- — Reach Break

N
W — E
S

0   350   700 Feet

Reach Y and Upper Z

GeoMorph®
Landuse and Surface ETEQ

Middle Tittabawassee River
Midland, Michigan

Drawn By:	JAT	Date: Oct. 14, 2007
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ET Project Number: 91803
ET Map File Location:
MTR proposed samples with landuse_20071014.mxd

Map labels:
- XY
- 528+00
- 530+00
- 532+00
- 534+00
- 536+00
- 538+00
- 540+00
- 542+00
- 544+00
- 546+00
- YZ
- 548+00
- 550+00
- 552+00
- 554+00
- 556+00
- 558+00
- 560+00
- 562+00

- 29-13-3-21-3008-000
- RY-540+00-SW695
- 29-13-3-28-1004-000
- RY-545+00-NE156
- RY-545+00-NE78
- RY-545+00-NE22
- RZ-555+00-N4
- 29-13-3-28-1002-001
- RZ-561+00-NE822
- RZ-561+00-NE571
- RZ-561+00-NE638
- RZ-561+00-NE915
- RZ-561+00-NE392
- RZ-561+00-NE240
- RZ-561+00-NE155
- RZ-561+00-NE198
- RZ-561+00-SW89
- RZ-561+00-NE19
- RZ-561+00-NE82
- RZ-561+00-NE258
- RZ-561+00-SW86
- RZ-565+50-NE1078
- RZ-565+50-NE968
- 29-13-3-28-2006-000

Overbank Samples and Land Use, " Middle Tittabawassee River"

Soil TEQ Concentration

Overbank:
- ● > 15,001 (red)
- ● 5,001 - 15,000 (orange)
- ● 1,001 - 5,000 (yellow)
- ● 101 - 1,000 (light green)
- ● < 100 (dark green)

- ● Proposed Samples
- ▭ Saginaw County Tax (Residential)
- ✓ Stations
- ▬ Reach Break

W N E S

0   350   700 Feet

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Drawn By:	JAT	Date: Oct. 14, 2007
Checked By:	PS	Edited By: JAT

Reach Lower Z and AA

GeoMorph®
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Middle Tittabawassee River
Midland, Michigan

ET Project Number: 91803
ET Map File Location:
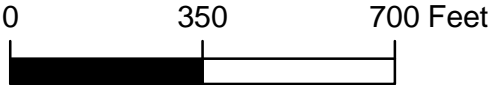MTR proposed samples with landuse_20071014.mxd

Overbank Samples and Land Use, " Middle Tittabawassee River"

Soil TEQ Concentration

overbank
- 🔴 > 15,001
- 🟠 5,001 - 15,000
- 🟡 1,001 - 5,000
- 🟢 101 - 1,000
- ⚪ < 100

- ⚫ Proposed Samples
- 🟧 Saginaw County Tax (Residential)
- ✓ Stations
- ▬ Reach Break

0   350   700 Feet

N
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S
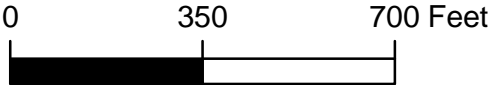
Drawn By: JAT **Date: Oct. 14, 2007**
Checked By: PS **Edited By:** JAT

Reach BB and Upper CC

GeoMorph®
Landuse and Surface ETEQ

Middle Tittabawassee River
Midland, Michigan

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ET Map File Location:
MTR proposed samples with landuse_20071014.mxd

RAA-601+00-NE288
RAA-601+00-NE322
RAA-601+00-NE256

29-13-3-27-3005-000

29-13-3-28-4001-007
RAA-596+50-SW168

AABB

606+00
598+00
600+00
602+00
604+00
606+00
608+00
610+00
612+00
614+00
616+00
618+00
620+00
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632+00

BBCC

634+00

636+00

638+00

RCC-639+00-SW9
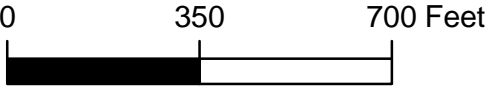RCC-639+00-SWS4
RCC-639+00-SW87
29-13-3-34-2004-005
RCC-639+00-SW258

Overbank Samples and Land Use, " Middle Tittabawassee River"

Soil TEQ Concentration

Overbank
- 🔴 > 15,001
- 🟠 5,001 - 15,000
- 🟡 1,001 - 5,000
- 🟢 101 - 1,000
- ⭕ < 100

- ● Proposed Samples
- ▮ Saginaw County Tax (Residential)
- ✐ Stations
- ▬ Reach Break

RCC-639+00-SW54
RCC-639+00-SW87
RCC-639+00-SW258
RCC-639+00-SW374
RCC-639+00-SW439
29-13-3-34-
2004-005

CCDD

DDEE

N
W E
S

0   350   700 Feet

Overbank Samples and Land Use, " Middle Tittabawassee River"

Soil TEQ Concentration

Overbank
- ● > 15,001
- ● 5,001 - 15,000
- ● 1,001 - 5,000
- ● 101 - 1,000
- ○ < 100

- ● Proposed Samples
- Saginaw County Tax (Residential)
- Stations
- Reach Break

DDEE

REE-680+50-SW485
REE-680+50-SW573
REE-680+50-SW865
REE-680+50-SW1188
REE-680+50-SW1232
REE-680+50-SW958
REE-680+50-SW1079

28-12-3-03-1001-003

REE-687+50-SW1412
REE-687+50-SW1094
REE-687+50-SW1253
REE-687+50-SW1021
REE-687+50-SW85
REE-687+50-SW743
REE-687+50-SW668

REE-694+00-SW1402
REE-694+00-SW1375
REE-694+00-SW1271
REE-694+00-SW857
REE-694+00-SW781
REE-694+00-S7

EEFF

682+00
684+00
686+00
688+00
690+00
692+00
694+00
696+00
698+00
700+00
702+00
704+00
706+00
708+00
710+00
712+00
680+00

23-12-3-02-2013-001

RFF-708+00-NE170
RFF-708+00-NE32
RFF-708+00-NE22

N
W E
S

0   350   700 Feet

Drawn By: JAT
Date: Oct. 14, 2007
Checked By: PS
Edited By: JAT

Reach EE and Upper FF

GeoMorph®
Landuse and Surface ETEQ

Middle Tittabawassee River
Midland, Michigan

ET Project Number: 91803
ET Map File Location:
MTR proposed samples with landuse_20071014.mxd

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Overbank Samples and Land Use, " Middle Tittabawassee River"
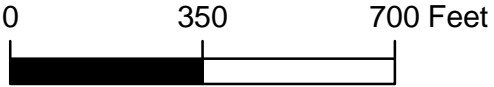

Soil TEQ Concentration

Overbank
- 🔴 > 15,001
- 🟠 5,001 - 15,000
- 🟡 1,001 - 5,000
- 🟢 101 - 1,000
- ⚪ < 100

- ⚫ Proposed Samples
- 🟧 Saginaw County Tax (Residential)
- ✎ Stations
- ▬ Reach Break

N W E S

0   350   700 Feet

23-12-3-02-2013-001
RFF-708+00-NE170
RFF-708+00-NE32
RFF-708+00-NE22

FFGG

GGHH
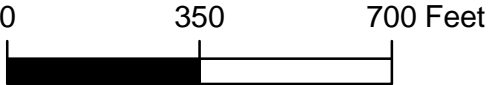
Attachment B

IRA/PCAP Step-out Sampling Plan

Tittabawassee River Site Investigation

IRA/PCAP STEP-OUT SAMPLING PLAN

A procedure has been established to initiate step-out sampling based on the thresholds identified in the IRA/PCAP Decision Tree. For sampling locations with reported concentrations that exceed the IRA/PCAP Decision Tree thresholds, step-out sampling to bound the lateral extent of the area will be initiated within 10 calendar days (Step 1. Delineation of Potential IRA/PCAP Area). Samples collected in conjunction with the step-out sampling will be processed on a Priority 1 analytical basis. In-channel step-out locations will be initiated with approximate 50 ft spacing around the location that exceeded the IRA/PCAP Decision Tree thresholds. Overbank locations will be initiated with approximate 100 ft spacing around the location that exceeded the IRA/PCAP Decision Tree thresholds. Electronic notifications will be sent to MDEQ within 3 calendar days of receiving data that indicates a sampling location exceeds the IRA/PCAP Decision Tree threshold levels. The electronic notification will include the following information:

a. Sample identification and concentration that exceeds the IRA/PCAP Implementation Decision Tree trigger criteria.

b. Confirmation that the appropriate step-out sampling will be initiated with in 10 calendar days and cores/samples/analyses will be processed on a Priority 1 basis

c. Sample identification of proposed step-out sampling locations

Laboratory results of the initial step-out sampling will be evaluated through the IRA/PCAP Decision Tree process. Step-out locations with concentrations that exceed the IRA/PCAP Decision Tree thresholds will result in additional step-out sampling to further bound the lateral extent of the area. As appropriate, additional step-out sampling will be initiated within 10 calendar days. Laboratory results generated through this process will be included in the monthly Site Investigation update.

Once the area that exceed the IRA/PCAP trigger level has been identified the next step (Step 2. Determine Need for IRA/PCAP) of the IRA/PCAP Implementation Decision Tree will be implemented.

Implementation of additional IRA/PCAP Implementation Decision Tree steps is dependent upon the results of the evaluation completed in Step 2.

Attachment C

Proposed Sampling Locations

LTR Priority 1 And 2 Properties

Legend

- ● Proposed Samples
- ▬ Reach Break
- ▭ Priority 2
- ▭ Priority 1

Geomorph Surfaces
- In-Channel
- Floodplain
- Wetland
- Natural Levee
- Natural Levee (Historic)
- Low Terrace
- Low Intermediate Terrace
- Intermediate Terrace
- High Terrace
- Upper High Terrace
- Upland

932+00

934+00

936+00

938+00

940+00

RNN-935+00-S2 RNN-935+00-S1

RNN-935+00-N1

RNN-935+00-N4
RNN-935+00-N3
RNN-935+00-N2

0   50   100   200
Feet

Drawn By: JT **Date:** Sept. 13, 2007

Checked By: PS; DR; BS **Edited By:** JT

GeoMorph Surfaces and Proposed Samples

LowerTittabawassee River

Midland, Michigan

Reach NN

ET Project Number: 91803
ET Map File Name:
gemorph surfaces 11x17 Reach nn to tt.mxd

ATS
ANN ARBOR TECHNICAL SERVICES, INC.

Legend

- Proposed Samples
- Reach Break
- Priority 2
- Priority 1

Geomorph Surfaces
- In-Channel
- Floodplain
- Wetland
- Natural Levee
- Natural Levee (Historic)
- Low Terrace
- Low Intermediate Terrace
- Intermediate Terrace
- High Terrace
- Upper High Terrace
- Upland

1030+00

QQRR

1032+00

1034+00

1036+00

1038+00

RRR-1034+00-S7

RRR-1034+00-S6

RRR-1034+00-S4

RRR-1034+00-S3

RRR-1034+00-S5

RRR-1034+00-S1

RRR-1034+00-S2

RRR-1034+00-N1

RRR-1034+00-N2

RRR-1034+00-N3

RRR-1040+50-N6

RRR-1040+50-N5

RRR-1040+50-N4

RRR-1040+50-N3

RRR-1040+50-N2

RRR-1040+50-N1

0   50   100   200
Feet

| Drawn By: | JT | Date: | Sept. 13, 2007 |
| Checked By: | PS; DR; BS | Edited By: | JT |

GeoMorph Surfaces and Proposed Samples

LowerTittabawassee River

Midland, Michigan

Reach RR

ET Project Number: 91803

ET Map File Name:
gemorph surfaces 11x17 Reach nn to tt.mxd

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GeoMorph Surfaces and Proposed Samples

LowerTittabawassee River

Midland, Michigan

Reach SS

ET Project Number: 91803
ET Map File Name:
gemorph surfaces 11x17 Reach nn to tt.mxd

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Drawn By: JT   Date: Sept. 13, 2007
Checked By: PS; DR; BS   Edited By: JT

Legend:
- Proposed Samples
- Reach Break
- Priority 2
- Priority 1
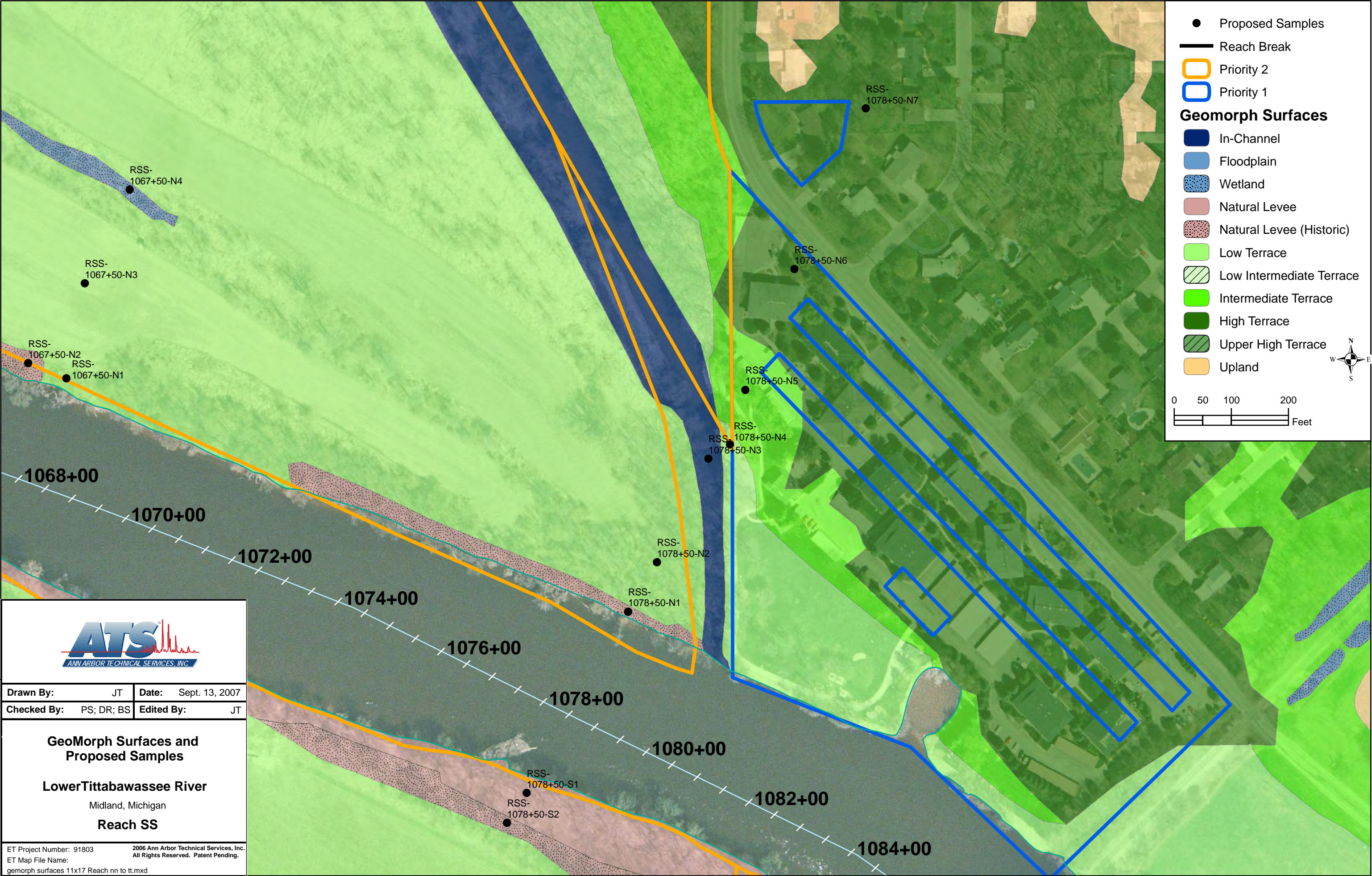
Geomorph Surfaces
- In-Channel
- Floodplain
- Wetland
- Natural Levee
- Natural Levee (Historic)
- Low Terrace
- Low Intermediate Terrace
- Intermediate Terrace
- High Terrace
- Upper High Terrace
- Upland

0 50 100 200 Feet

Sample labels:
- RSS-1067+50-N4
- RSS-1067+50-N3
- RSS-1067+50-N2
- RSS-1067+50-N1
- RSS-1078+50-N7
- RSS-1078+50-N6
- RSS-1078+50-N5
- RSS-1078+50-N4
- RSS-1078+50-N3
- RSS-1078+50-N2
- RSS-1078+50-N1
- RSS-1078+50-S1
- RSS-1078+50-S2

Station labels: 1068+00, 1070+00, 1072+00, 1074+00, 1076+00, 1078+00, 1080+00, 1082+00, 1084+00

GeoMorph Surfaces and Proposed Samples

LowerTittabawassee River

Midland, Michigan

Reach TT

Legend:

- Proposed Samples
- Reach Break
- Priority 2
- Priority 1

Geomorph Surfaces

- In-Channel
- Floodplain
- Wetland
- Natural Levee
- Natural Levee (Historic)
- Low Terrace
- Low Intermediate Terrace
- Intermediate Terrace
- High Terrace
- Upper High Terrace
- Upland

0 50 100 200
Feet

RXX-1244+50-N4

RXX-1244+50-N3

RXX-1253+00-N4

RXX-1253+00-N3

RXX-1253+00-N2

RXX-1253+00-N1

1246+00

1248+00

1250+00

1252+00

1254+00

1256+00

1258+00

1260+00

ATS
ANN ARBOR TECHNICAL SERVICES, INC.

Drawn By:	JT	Date:	Sept. 13, 2007
Checked By:	PS; DR; BS	Edited By:	JT

GeoMorph Surfaces and Proposed Samples
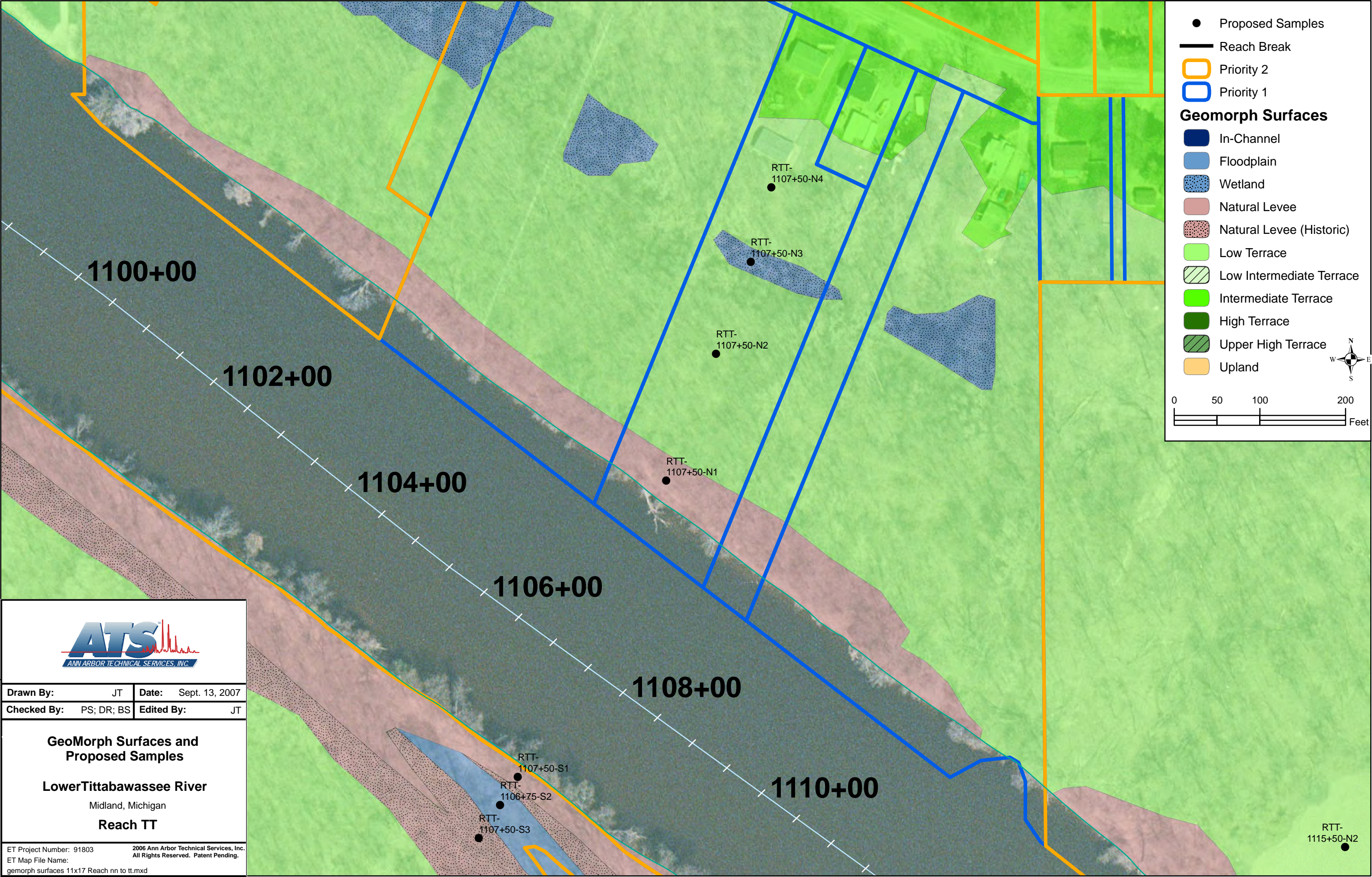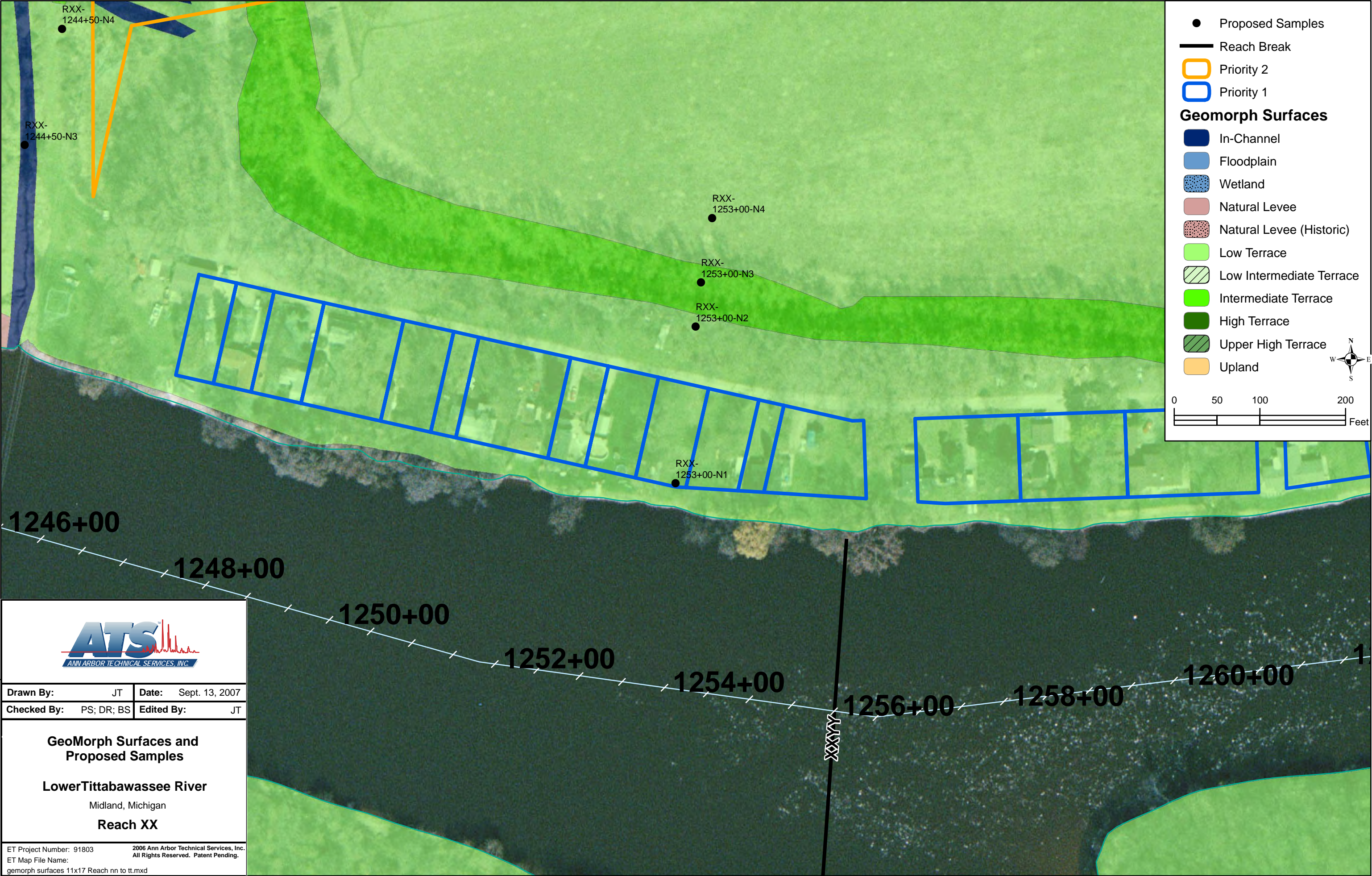
Lower Tittabawassee River

Midland, Michigan

Reach XX

ET Project Number: 91803
ET Map File Name:
gemorph surfaces 11x17 Reach nn to tt.mxd

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Attachment D

Example: Descriptive Statistics

Statistical Evaluation
UTR Reach L – Upper High Surface

Sampling Approach:
- Fixed Interval (12)
- GeoMorph (7)

Geomophic Surface:
- Upper High
- 17.5 acres
- Agricultural/Rangeland

Geomorphic Proximity:
- Away

Statistical Evaluation
Reach L Fixed Interval Dataset

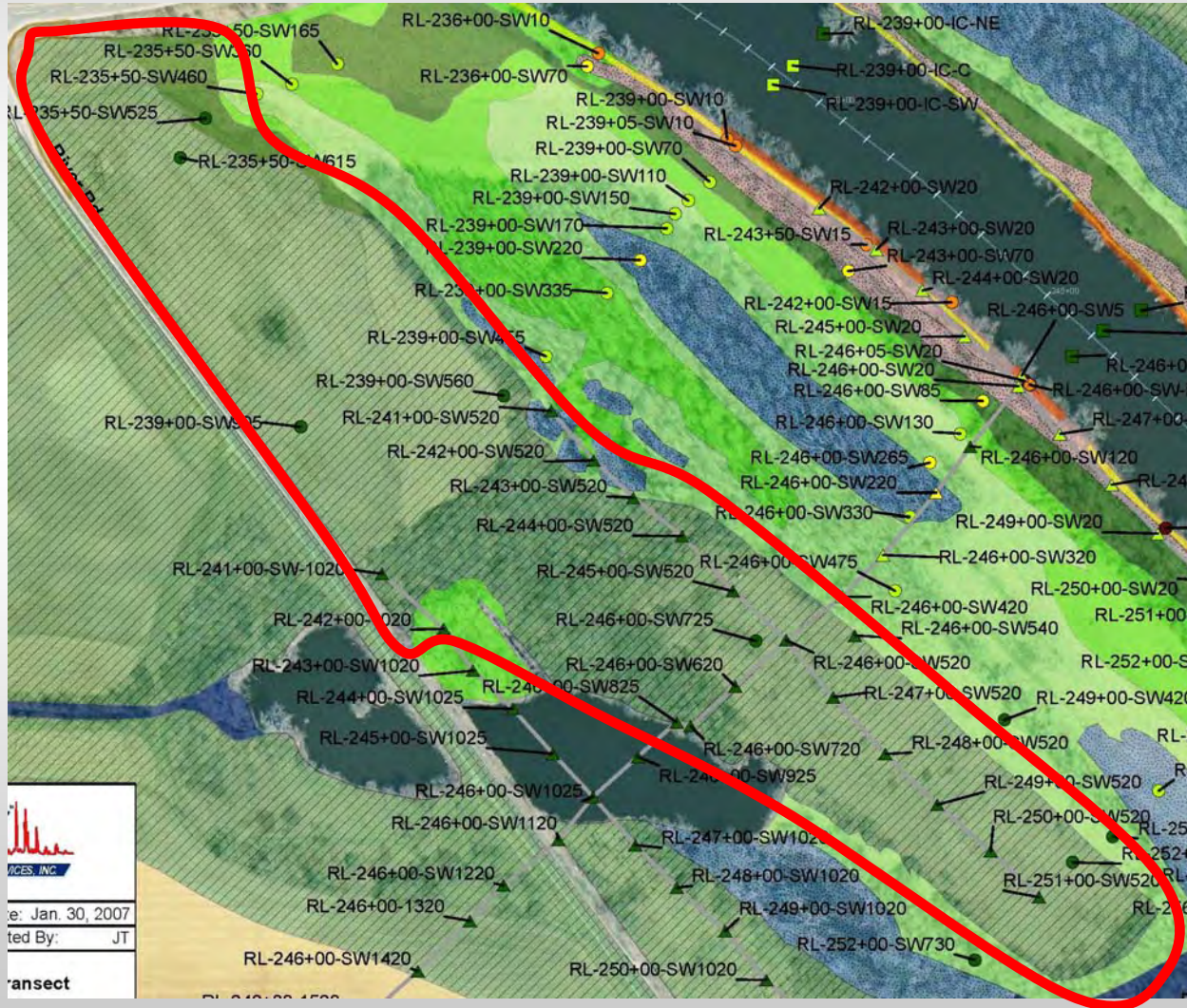| Transect Location/Sample Identification	Depth Interval (ft,bgs)	Geomorphic Surface	Geomorphic Proximity	Max. ETEQ (ppt)
Fixed Interval Locations				
RL-241+00-SW1020	0.0-1.0	Upper High	Away	12
RL-243+00-SW520	0.0-1.0	Upper High	Away	12
RL-244+00-SW520	0.0-1.0	Upper High	Away	12
RL-245+00-SW520	0.0-1.0	Upper High	Away	12
RL-246+00-SW520	0.0-1.0	Upper High	Away	11
RL-246+00-SW620	0.0-1.0	Upper High	Away	14
RL-246+00-SW720	0.0-1.0	Upper High	Away	12
RL-247+00-SW520	0.0-1.0	Upper High	Away	10
RL-248+00-SW520	0.0-1.0	Upper High	Away	11
RL-249+00-SW520	0.0-1.0	Upper High	Away	14
RL-250+00-SW520	0.0-1.0	Upper High	Away	13
RL-251+00-SW520	0.0-1.0	Upper High	Away	17

n =	12
(n-1) =	11
Min. =	10
Max. =	17
St. Dev. =	1.8
Mean =	13
Median =	12
Geomean =	12
CV =	0.15
Skewness =	1.3
t (0.95, n-1) =	1.8
95% UCL Mean =	13
95% UCL Median =	13

Statistical Evaluation
Reach L GeoMorph Dataset

Transect Location/Sample Identification	Depth Interval (ft,bgs)	Geomorphic Surface	Geomorphic Proximity	Max. ETEQ (ppt)
GeoMorph Locations				
RL-235+50-SW615	0.0-0.6	Upper High	Away	14
RL-246+00-SW725	0.0-1.2	Upper High	Away	14
RL-252+00-SW495	0.0-0.9	Upper High	Away	14
RL-239+00-SW560	0.0-0.6	Upper High	Away	10
RL-239+00-SW905	0.0-0.6	Upper High	Away	10
RL-246+00-SW540	0.0-0.6	Upper High	Away	10
RL-246+00-SW825	0.0-0.5	Upper High	Away	10
			n =	7
			(n-1) =	6
			Min. =	10
			Max. =	14
			St. Dev. =	4.6
			Mean =	12
			Median =	10
			Geomean =	12
			CV =	0.39
			Skewness =	0.4
			t (0.95, n-1) =	1.9
			95% UCL Mean =	15
			95% UCL Median =	13

Statistical Evaluation
Reach L Combined Dataset

| Transect Location/Sample Identification	Depth Interval (ft,bgs)	Geomorphic Surface	Geomorphic Proximity	Max. ETEQ (ppt)
Combined				
RL-239+00-SW560	0.0-0.6	Upper High	Away	10
RL-239+00-SW905	0.0-0.6	Upper High	Away	10
RL-246+00-SW540	0.0-0.6	Upper High	Away	10
RL-246+00-SW825	0.0-0.5	Upper High	Away	10
RL-247+00-SW520	0.0-1.0	Upper High	Away	10
RL-246+00-SW520	0.0-1.0	Upper High	Away	11
RL-248+00-SW520	0.0-1.0	Upper High	Away	11
RL-241+00-SW1020	0.0-1.0	Upper High	Away	12
RL-243+00-SW520	0.0-1.0	Upper High	Away	12
RL-244+00-SW520	0.0-1.0	Upper High	Away	12
RL-245+00-SW520	0.0-1.0	Upper High	Away	12
RL-246+00-SW720	0.0-1.0	Upper High	Away	12
RL-250+00-SW520	0.0-1.0	Upper High	Away	13
RL-235+50-SW615	0.0-0.6	Upper High	Away	14
RL-246+00-SW725	0.0-1.2	Upper High	Away	14
RL-252+00-SW495	0.0-0.9	Upper High	Away	14
RL-246+00-SW620	0.0-1.0	Upper High	Away	14
RL-249+00-SW520	0.0-1.0	Upper High	Away	14
RL-251+00-SW520	0.0-1.0	Upper High	Away	17

n =	19
(n-1) =	18
Min. =	10
Max. =	17
St. Dev. =	1.9
Mean =	12
Median =	12
Geomean =	12
CV =	0.16
Skewness =	0.7
t (0.95, n-1) =	1.7
95% UCL Mean =	13
95% UCL Median =	13

Attachment E

Example: SWAC polygons

SWAC Polygon
UTR Reach L – Upper High Surface
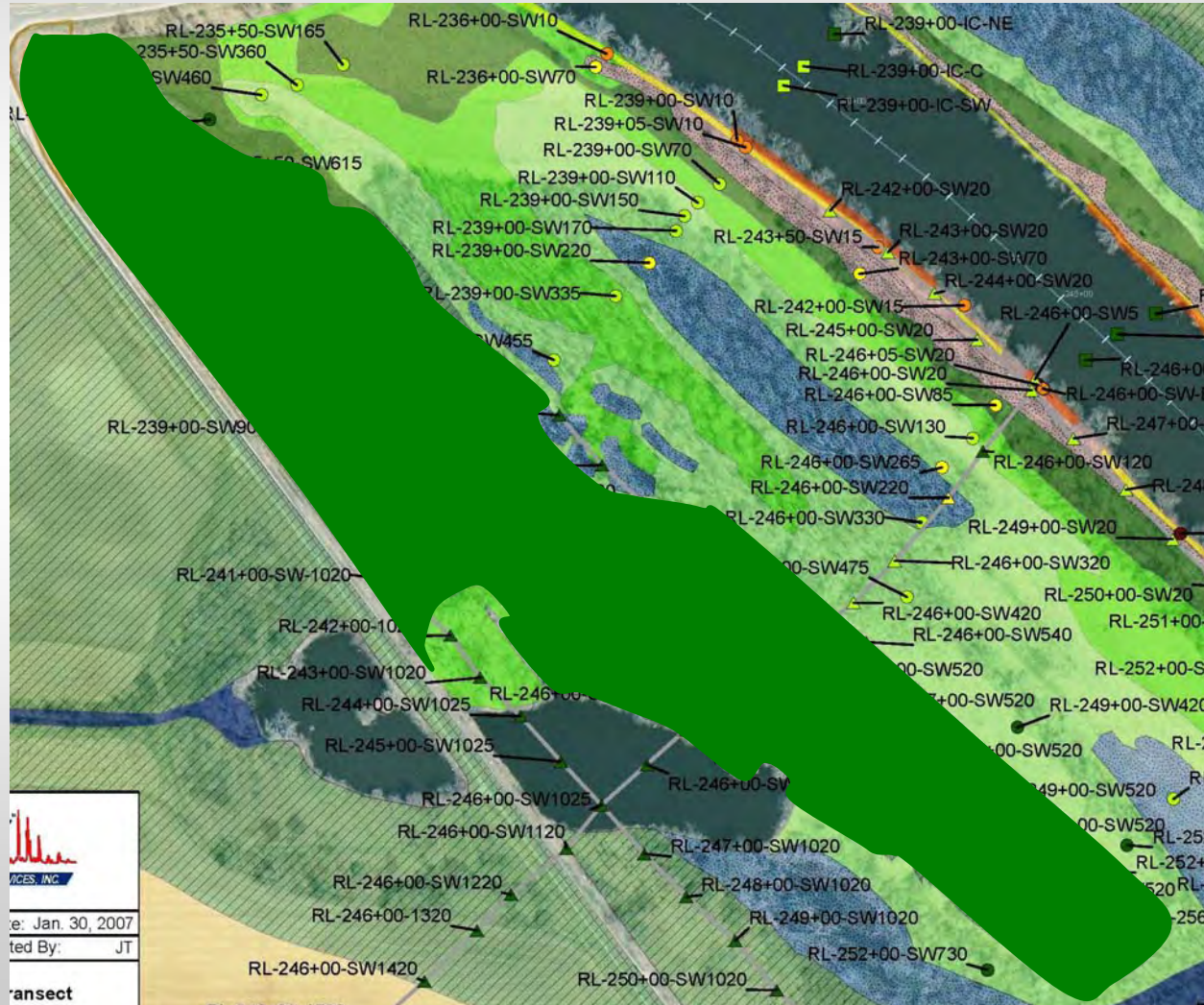
Attachment F

Example: Adequacy of Characterization Analysis

Example: HARP Segment 7 All Bank Dataset Statistics Evaluation and SWAC Calculation

Sample ID	STATION ID	SAMPLE CONCENTRATION (ppm)	RISK ATTENUATION FACTOR	ADJUSTED CONCENTRATION (ppm)	AREA (sq. ft.)	PPM x Area (ppm*sq.ft.)	Area (acres)
S4-03-2W	127	0.26	1	0.26	266.0	69.2	0.01
FVD-SS-79	2	0.54	1	0.54	1622.3	876.0	0.04
S4-03-4E	129	2.4	1	2.4	1776.0	4,262.5	0.04
S7-8+80+E5	9	2.0	1	2.0	4190.2	8380.4	0.10
S7-14+30-W10	12	4.3	1	4.3	4572.3	19660.9	0.10
PRV-FVD-G3-FLOOR (*)	60	0.02	1	0.02	324.8	6.5	0.01
PRV-FVD-SD14-FLOOR (*)	62	0.02	1	0.02	87.1	1.7	0.00
PRV-C2-SW (*)	65	0.2	1	0.2	365.2	73.0	0.01
PRV-FVD-G3-SW (*)	59	0.2	1	0.2	468.5	93.7	0.01
S7-A3	18	0.56	1	0.56	1456.5	815.6	0.03
FVD-SS-G1	49	1.1	1	1.1	3934.0	4327.4	0.09
PRV-C4-SW (*)	68	2	1	2	523.3	1046.6	0.01
PRV-FVD-SD14-SW (*)	61	2	1	2	86.8	173.7	0.00
S7-B4	25	3	1	3	1750.7	5252.1	0.04
PRV-D1-MSW (*)	72	0.02	1	0.02	72.8	1.5	0.00
PRV-D2-SSW (*)	76	0.02	1	0.02	147.3	2.9	0.00
PRV-D4-N-MSW (*)	90	0.02	1	0.02	257.1	5.1	0.00
PRV-D4-S-SSW (*)	86	0.02	1	0.02	6.2	0.1	0.00
PRV-E4-W-FLOOR (*)	96	0.02	1	0.02	485.1	9.7	0.01
PRV-D1-SSW (*)	73	0.2	1	0.2	370.5	74.1	0.01
PRV-D2/D3-MSW (*)	80	0.2	1	0.2	148.4	29.7	0.00
PRV-D3-MSW (*)	84	0.2	1	0.2	208.8	41.8	0.00
PRV-D4-N-SSW (*)	89	0.2	1	0.2	35.2	7.0	0.00
PRV-E4-E-MSW (*)	99	0.2	1	0.2	141.6	28.3	0.00
PRV-E4-W-MSW (*)	95	0.2	1	0.2	856.4	171.3	0.02
PRV-D2/D3-SSW (*)	79	2	1	2	136.2	272.4	0.00
PRV-D2-MSW (*)	77	2	1	2	624.2	1248.5	0.01
PRV-D3-SSW (*)	83	2	1	2	1520.0	3039.9	0.03
PRV-D4-S-MSW (*)	87	2	1	2	263.1	526.2	0.01
PRV-E4-E-SSW (*)	98	2	1	2	109.7	219.4	0.00
PRV-E4-W-SSW (*)	94	2	1	2	100.0	200.0	0.00
PRV-FVD-H4-SSW (*)	107	0.02	1	0.02	1133.1	22.7	0.03
PRV-PB+30-SW (*)	101	0.2	1	0.2	641.0	128.2	0.01
PRV-FVD-H2-SW (*)	104	2	1	2	1820.1	3640.3	0.04
PRV-H1-SW (*)	112	0.02	1	0.02	7118.4	142.4	0.16
PRV-G1-FLOOR (*)	111	0.2	1	0.2	169.7	33.9	0.00
PRV-G1-SW (*)	110	2	1	2	5446.5	10893.0	0.13
PRV-H1-FLOOR (*)	113	2	1	2	166.3	332.5	0.00
PRV-FVD-I1-Floor (*)	118	0.02	1	0.02	309.5	6.2	0.01
PRV-FVD-I4-SW (*)	123	0.02	1	0.02	891.3	17.8	0.02
PRV-PB-50+00-SW (*)	131	0.02	1	0.02	277.1	5.5	0.01
PRV-FVD-I1-SW (*)	117	0.2	1	0.2	592.4	118.5	0.01
PRV-FVD-I3-Floor (*)	121	0.2	1	0.2	318.3	63.7	0.01
PRV-FVD-I4-Floor (*)	124	2	1	2	639.1	1278.3	0.01
PRV-FVD-I6-SW (*)	114	2	1	2	16.5	33.1	0.00
PRV-PB-50+00-FLOOR (*)	132	2	1	2	294.5	589.0	0.01

	Totals =	46740.5	68,222.3	1.07

Total Surface Weighted Average Concentration = 1.46 ppm

Risk Modifier

< 2" of Soil Cover (Risk Attenuation Factor = 1)
2" to 6" of Soil Cover (Risk Attenuation Factor = 0.5)
> 6" of Soil Cover (Risk Attenuation Factor = 0.1)
> 6" Soil Cover or Rip Rap Plus Geotextile (Risk Attenuation Factor = 0.01)

n =	46
(n-1) =	45
Average =	0.97
Standard Deviation =	1.07
Max =	4.30
CV =	1.10
Min=	0.02
Skewness =	0.89
t (0.95,n-1) =	1.68
95% UCL =	1.24

Example: HARP Segment 7 All Bank Dataset Adequacy of Characterization Analysis

INPUT

PCB Concentrations

mean	0.97
st dev	1.07
n	46

Segment 7 Scope of Work

35	Existing Site Characterization Samples
40	Proposed Post Removal Verification Samples ("Confirmation Samples")

Action Level: 1 mg/kg

		Number of Samples			
alpha	beta	delta = 0.1 mg/kg	delta = 0.2 mg/kg	delta = 0.5 mg/kg	delta = 1.0 mg/kg
0.01	0.01	2,879	722	119	32
0.05	0.05	1,439	361	60	16
0.05	0.10	1,139	286	48	13
0.10	0.05	1,139	286	47	13
0.10	0.10	874	220	36	10

Action Level: 2 mg/kg

		Number of Samples			
alpha	beta	delta = 0.2 mg/kg	delta = 0.4 mg/kg	delta = 1.0 mg/kg	delta = 2.0 mg/kg
0.01	0.01	722	183	32	11
0.05	0.05	361	92	16	6
0.05	0.10	286	73	13	5
0.10	0.05	286	73	13	4
0.10	0.10	220	56	10	4

Action Level: 5 mg/kg

		Number of Samples			
alpha	beta	delta = 0.5 mg/kg	delta = 1.0 mg/kg	delta = 2.5 mg/kg	delta = 5.0 mg/kg
0.01	0.01	119	32	8	5
0.05	0.05	60	16	4	3
0.05	0.10	48	13	4	3
0.10	0.05	47	13	3	2
0.10	0.10	36	10	3	2

Action Level: 10 mg/kg

		Number of Samples			
alpha	beta	delta = 1.0 mg/kg	delta = 2.5 mg/kg	delta = 5.0 mg/kg	delta = 15 mg/kg
0.01	0.01	32	11	5	4
0.05	0.05	16	6	3	2
0.05	0.10	13	5	3	2
0.10	0.05	13	4	2	2
0.10	0.10	10	4	2	1

alpha = False Rejection Rate (e.g., 0.05 = 95% CL)
beta = False Acceptance Rate (e.g., 0.05 = 95% CL)
delta = "Gray Region" Above Action Level

Sample Size Necessary to Achieve False Positive & False Negative Rates

Assumptions:
- All sample concentrations
- No risk/probability modifiers
- Not required to be normally distributed
- True mean >= action level, "assumes site is dirty"

Alpha = False Rejection Rate (e.g., 0.05 = 95% CL)

Beta = False Acceptance Rate (e.g., 0.05 = 95% CL)

Delta = Gray Region > Action Level